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16. Abstract

The note discusses the mineral and chemical composition of the Kabakly stony meteorite found in the Kara Kum sandy waste in 1968. According to the chemical analysis, the meteorite belongs to the H-group of meteorites.

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THE STONY KABAKLY METEORITE

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The stony Kabakly meteorite was found in 1965, but only became known in 1968 (Meteoritnyy byulleten', 1969). /90*

The meteorite was found in the northern part of the Kara Kum sandy waste in the Deynausk district(rayon) of the Turkmen SSR, approximately 350 km west-northwest of the settlement of Kabakly.

The meteorite was found by B. V. Podlipalin, a veterinary technician, and was sent by him to A. A. Boyarshchikov, a land reclamation technician, for transmission to the Committee on Meteorites of the USSR Academy of Sciences, which received it on November 5, 1968.

B. V. Podlipalin, in letters of December 21, 1968 and January 14, 1969, reported that the meteorite was discovered by him on March 23, 1965 at 350 km west-northwest of the settlement of Kabakly, 18 km from the Kerven well, and 300 m from the Yany Kuduk well (a new well. Former name Madamy-bay). All the distances were determined extremely approximately. Podlipalin, then working as a veterinary technician at the Deynausk station for control of diseases of farm animals at the Karl Marx kolkhoz, was tending the flocks which were still in summer pastures.

In "settled sands," dense and covered with vegetation, he noticed a "small, exact cone" with diameter of about 30-40 cm and depth of 10-15 cm in which a "black pebble" lay. Podlipalin identified it, by virtue of its weight, as a meteorite.

*Numbers in the margin indicate pagination in the foreign text.

The Kabakly meteorite appears to be an individual specimen weighing 71.6 g (sample 15007). It was an irregular polyhedron, reminiscent of an iron with a truncated spout (photogram 2) *. Its entire surface was covered with a lusterless fusion crust, brownish-black with a strong reddish tint from iron hydroxides formed during terrestrial weathering. The larger (of the three) faces are flat. A front and a rear surface can be distinguished. The frontal part is in the form of a smooth, irregular, rectangular pyramid with rounded edges and a truncated displaced vertex (photogram 2; a, b).

The rear surfaces and one lateral surface are in sufficiently deep regmaglypts with diameter sometimes greater than 1 cm. A prominence can be seen projecting from one of the large side surfaces through whose base passes a fissure intersecting the dark brown fusion crust. Near one edge of the fusion crust fissure, part of the matter bounced off and a triangular cavity was formed (photogram 2; c).

The meteorite was sawed across the longitudinal axis, and a plate was sawed from its larger part, which was then used for preparing a thin slice for chemical analysis. The weight of the larger rear part following this amounted to about 38 g and that of the lesser frontal part, 22.4 g. The saw-cut planes with area of 29 mm x 27 mm and 26 mm x 25 mm were polished. The meteo- /91
rite was cut with a carborundum disc of 0.8 mm thickness. The loss of meteoritic matter from cutting and polishing amounted to about 6 g.

A dense stony mass of chondrite, generally rusty in color with an irregular distribution of light sections and with numerous particles of silver iron, was seen on the saw-cut planes. Elongated particles, some up to 2 mm in length, with a tendency toward

*Translator's Note: none of the photos mentioned are reproduced here.

subparallel arrangement were observed among them. Other, more minute, irregular particles were arranged in annuli around a chondrule. A particle of nickel iron with length of about 7 mm and width of 2 mm (photogram 2; d, e) was seen on the saw-cut planes of the larger lump.

Under a microscope it was seen in thin slices that the Kabakly meteorite is an inhomogeneously structured chondrite, oxidized under terrestrial conditions. Terrestrial weathering expressed, apart from the burnishing of the fusion crust and of the surface cracks, in abundant stringers of iron hydroxide increases the brecciated appearance of the meteorite. Iron hydroxides color the microsections to a brownish-rust tint in spots.

The Kabakly meteorite, as can be seen under a microscope, consists of fragments, namely sections of crystalline chondrite between which a semitransparent brown matter is distributed containing the chondrules, their fragments, and grains of silicates and grains of opaque minerals (photogram 3; a).

The fragments of the crystalline chondrite measure 5 mm x 4 mm and more in area (according to three thin slices whose total area was about 20 mm x 10 mm), have a distinct, often rectangular shape, sharp contours, though usually rounded corners as if smoothed, we may assume, by terrestrial oxidation. They consist of an aggregate of silicates and opaque minerals, generally of a crystalloblastic, unequigranular texture and a centric texture, as is typical for recrystallization. Opaque minerals, to which plagioclase acid is frequently added, usually are the core of the silicate concretions. Traces of recrystallized chondrules and, frequently, well preserved chondrules, can be distinguished in the middle of this aggregate.

The original chondrite structure of these sections is also evident from the annular arrangement of the opaque minerals (photogram 3; b).

The fragmental silicates are represented by olivine and orthopyroxene. They are either comparatively large grains with a diameter of up to 0.3 mm, or minute and fine granular aggregates with individual diameters of less than 0.1 mm. The larger grains usually have undulating extinction and in places are apparently displaced by the fine-granular aggregate, which are relict sections of former glass. Orthopyroxene, in addition, is observed in the form of occluded minute grains in sections with traces of eccentric-radiated chondritic texture. It should be noted that olivine and orthopyroxene are in places difficult to distinguish in thin slices due to the thickness of the latter, which exceeds 30 μ. The silicates, like the entire fragmental aggregate and the entire meteorite, is highly fractured.

A chondrule with a diameter of about 0.8 mm and with a complicated barred texture (photogram 3; b) was encountered in one of the fragments of the crystalline chondrite. The bars of the components of its two monocrystals of olivine made of granules of olivine arranged in networks are distinguished by narrow bands of plagioclase acid. Separate beams of a skeletal olivine crystal in the other chondrule are composed of granules of olivine arranged in beads, which are as if embedded in an aggregate of plagioclase granules. The opaque minerals, about which we shall speak below, are quite uniformly distributed, but are distinguished by size.

The fragmental embedding mass, frequently in the form of prolate sections, are more heavily saturated with iron oxides, "schistosity" being observed in places in it. Chondrules, most frequently minute, in rounded and elliptically shaped sections, fragments of chondrules, minute fragments of crystalline chondrites and silicate grains, and opaque minerals (photogram 3; c) can be seen in this rust-brown mass. The diameter of the chondrules varies from less /92 than 20 μ up to greater than 1 mm, chondrules with dimension of 0.3-0.4 mm predominating. The textures of the chondrules are distinctive; most of the chondrules are holocrystalline, though minute chondrules made of weakly decrystallized glass are encountered. Idiomorphic olivine crystals with dimensions of from 140 μ x 70 μ to 26 μ x 20 μ and less, contained in the brownish mass, in which bundles of fine prismo- or orthopyroxene can be distinguished, are seen in one of the chondrules. Not only othopyroxene, but clinopyroxene as well, is observed in the composition of the chondrule of the embedding mass.

Coarse fragments of olivine monocrystals, frequently broken into pieces, are encountered; separate sections of them are shifted relative to each other by fractures filled with an opaque matter or, more rarely, with fine-granular olivine. Olivine in the separate grains (of the chondrules) displays a zonality.

Olivine and orthopyroxene are the essential minerals of both the fragments as well as of their embedding chondrite in the Kabakly meteorite.

Olivine. Olivine contains from about 16 to 19 mol.-% Fa in a number of grains from different sections of the meteorite, according to the index of refraction, which varied from 1.702 to 1.710 for Ng, from 1.680 to 1.686 for Nm, and from 1.663 to 1.675 for Np, and according to the angle of the optical axes, which was close to 90° (Dir et al., Vol. 1, 1965).

All of the pyroxenes of the fragments of crystalline chondrites and, for the most part, pyroxene from the embedding chondrite, are orthopyroxenes. According to parallel extinction, the maximum index of refraction for Ng of 1.689 $\pm$ 0.005, and according to the angle of the optical axes 2V $\geq$ 80°, they belong to bronzite with 17-19 mol.-% Fs (Dir et al., Vol. II, 1965). Chondrules, in whose composition clinopyroxene also participates, are encountered in the embedding fragment of the crystalline chondrites, in addition to the orthopyroxene. It is observed in the form of irregularly shaped grains, characterized by its polysynthetic twins. According to the angle of extinction, which varies from 20° to 30°, and according to the maximum index of refraction for Ng of 1.681 $\pm$ 0.006, it belongs to clinobronzite.

Feldspar is observed under the microscope in chondrules and in centric concretions of only the fragments of the crystalline chondrites. It forms typical sections from minute isometric granules, has low birefringence and refraction; its average index of refraction Nm ≈ 1.530 $\pm$ 0.006. According to these data it also belongs to albite-oligoclase.

Particles of nickel iron and grains of troilite, as is evident in polished sections in transmitted light, are quite uniformly distributed, though are different according to dimensions: (1) large and usually elongated nickel-iron particles of length up to 1.5-2 mm and width up to 0.5-0.7 mm. The number of such particles is small and they often are found in concretions with the same coarse mono-crystalline grains (having the color of a copper-zinc alloy) of fractured troilite; (2) particles with diameters from 0.4 x 0.5 to 0.6 x 1 mm of an amoeboid or irregular, though quite isometric form. Their number is considerable. The largest of these particles are often closely associated with silicate grains with minute drop-like granules of troilite, which creates an imprint of the separate fragments; (3) minute particles, more or less isometric, with diameters of 0.1-0.2 mm. They are particularly abundant in fragments of crystalline chondrites.

Nickel-iron particles of average diameter and amoeboid shape in elongated sections of the embedding masses belonging to a monocrystal are often joined to each other, as if stretched, causing some schistosity of these sections (photogram 3; d).

Ordinary micropickling with 2% and 5% nital showed that the nickel-iron particles have a distinct compositon and texture. Some of the most minute particles were pickled for 2-3 sec; they are kamacite, frequently with sections of taenite or with fields of dense plessite and marginate taenite. The other minute particles were not pickled for very long, on the basis of which they belong /93 to taenite. Particles of average diameter are usually pickled rapidly and are fragments of monocrystalline kamacite or polycrystalline kamacite, which can be easily determined from the Neumann lines. Sections of taenite or plessite surrounding a fringe of taenite (photogram 3; e) are frequently included in the kamacite. These sections frequently directly adjoin the troilite grains.

The largest particles belong to monocrystalline or polycrystalline kamacite, usually with deformed Neuman lines. Rounded sections of comparatively coarse granular, microoctahedritic plessite (photogram 3; f) are observed within some of them.

In addition to these particles, nickel iron in the form of thin rust traces is observed in separate silicate grains.

Troilite, as is usual, is in more isometric grains than is nickel iron. The larger ones are more noticeably colored than are the minute ones. It is also encountered in the form of thin rust traces and in the form of stringers confined to the fusion crust and adjoining its sections, and in the form of polycrystalline sections, as if carburizing the silicates.

Separate grains of chromite are encountered with diameters in fractions of a millimeter. Terrestrial oxidation of the nickel-iron and troilite particles is expressed in the appearance in places of thin fringes of iron oxides, often of iron hydroxides, that reach a thickness of 0.1 mm, sometimes having a zonal structure and in networks of strings abundantly running through the meteorite. Sections are encountered wholly complicated with concentrically arranged iron oxides. They are often near the fusion crust.

A count by means of a linear ocular micrometer showed that the number of minerals in polished sections (total length of the lines was more than 8 cm) comprising the meteorite amounts to (in vol.-%): nickel iron-4.87, troilite--2.8, silicates (+ impurity minerals + products of terrestrial weathering)--92.33. In scaling on the basis of weight-per cent this amounts to (the accepted specific weight of the mineral is shown in parentheses) 10.96 (7.8), 3.8 (4.7), and 85.24 (3.2), respectively.

Results of a chemical analysis conducted by M. I. D'yakonova are presented in the table. Part of the sawed-off flakes with total weight of 4.5 g was analyzed. The sample was fragmented with difficulty in preparing the assay for analysis due to its great hardness.

The nonmagnetic part of the meteorite amounted to 75.24 wt.-%, /94 and the magnetic part amounted to 24.76 wt.-%. The part soluble in acids (aqua regia 3HCl + 1 HNO_3) was 46.32, and the insoluble part was 53.68 wt.-%.

According to the data of the chemical analysis, the meteorite may belong to the H-group of meteorites (Urey, Craig, 1953).

Chemical Composition of the Malakly Meteorite*

Oxide	Wt.-%	Elements	Wt.-%
SiO_2	37,07	Fe	14,88
TiO_2	0,11 (0,107)	Ni	1,55
Al_2O_3	2,02	Co	0,101
FeO	10,13	Fe, Ni, Co	16,531
MnO	0,25		
MgO	24,36	S	2,12
CaO	2,20		
Na_2O	0,60	Fe sulphides	3,71
K_2O	0,066		
P_2O_5	0,36	FeS	5,83
Cr_2O_3	0,52		
H_2O^+	0,61	Sum total	100,90
H_2O^-	0,25	Density	=3,46 g/cm³
Sum of silicate part	78,54		

* Content of Fe_{tot} was equal to 26.46%, Ni content in metal was 9.38%.

[Translator's Note: commas represent decimals]

Consequently, as a result of the investigations conducted, the stony Kabakly meteorite was shown to be a brecciated textured chondrite. It consists of fragments of a crystalline chondrite included in a recently formed chondrite close in composition to these fragments.

Oxidation under terrestrial conditions somewhat obscures the structure of the meteorite, though it most probably belongs to the Wahl polymitic breccia (Wahl, 1952) or to the Binns xenolithic chondrites (Binns, 1967).

According to silicate composition, the fragments and their embedding mass belong to the bronzite-olivine chondrites (Prior, 1920), corresponding to Urey and Craig's Group H . In addition, the silicate composition is uniform in the fragments and varies somewhat in the embedding mass, which, moreover, contains clinobronzite and weakly decrystallized glass and does not contain plagioclase.

The quantity of nickel iron in the Kabakly meteorite estimated under a microscope is lower than is usually observed in this group of chondrites (11% as opposed to an average of 17%), but it is also lower than the chemically determined nickel-iron content of the corresponding H group. The divergence in nickel-iron content, as well as in troilite content (see above), evidently must be adjusted on account of the oxidation of the meteorite in terrestrial conditions and in part on account of the inhomogeneity of the meteorite.

In conclusion we should note that the "brecciated" structure of the chondrite, analogous to that observed in meteorites of abundant meteoric rains, permits us to suppose that the specimen found is not unique.

Report read at the Fourteenth Meteoritics
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